Scientists – Performers – Audiences: Different modes of meaning-making[1]

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Performance practices such as dance, theatre, rituals, popular entertainments, sports, and professional rhetoric are key elements of many cultures [Bial 2007], each developed over centuries with varied functions attached to its different forms. Here, the focus is on classical dances and western definitions of theatre dance [Pavis 1996]. While imitation has been suggested to play a central role in the making and receiving of dance [Laland *et al.* 2016: 5-9; Cohen 1953: 232-236], it has become particularly evident over the last century of research, that scientists, performers, and audiences have different modes of meaning-making in regards to dance. Dancers' understanding can be best described as predominantly embodied [Daly 2002], dancers are encouraged and have learnt to make meaning out of their dance experience. With adequate input and individuals' reflective efforts, dancers' meaning-making is also informed by conceptual knowledge [Moffett 2012: 1-6] and cultural/socio-economic understanding [Sööt & Viskus 2013: 1193]. Audience members, who do not participate in dance themselves, can be expected to gain different forms of understanding, likely dependent on their individual motivations and tastes to see and experience dance [Reason and Reynolds 2010: 49-75]. Empirical evidence showed indeed how audiences' meaning-making is shaped by their personalities amongst other factors, such as their expertise as dance spectators and dance practitioners [Jola *et al.* 2014: 11].

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Meaning-making through scientific inquiry is strongly driven by a set of fundamental research principles. These principles set out a well-defined and, within the community, conscientiously shared conceptual (theoretical) and methodological approach to knowledge building. These principles have often been linked to discipline-specific paradigms, i.e., standards for the type of approaches that lead to recognized contributions in a specific field. One limitation of such paradigms is the reductionism in regard to the type of data and the type of stimuli used. The former relates to the idea that research has to take place within a certain methodology. For example, it has been postulated that research has either a qualitative or quantitative approach as the types of data cannot be mixed [Johnson *et al.* 2004: 14-26]. Reductionism in the stimuli used in experimental research is based on the assumption that complex phenomena, such as for instance dance, can be understood by the analysis of their individual parts. Dissecting a phenomenon may support data clarity, enhances reliability of the data, and facilitates interpretation. Yet one could argue that due to the reduction of the stimulus complexity, interpretations and applicability of the research, findings are limited. For example, the meaning-making of dance by scientists could be deemed incomparable to the meaning-making by dancers and audiences due to the reductionist approach [Jola *et al.* 2012: 17-37]. One way to fully capture the phenomenon of dance would be to include the perspective of the scientists, the dancers, the audiences, as well as other dance related practitioners (i.e., the choreographer, the theatre directors, and so on, including the contexts). Here, the aim is not to provide a complete picture of meaning-making. The text focuses instead on the meaning-making of the scientist, from a critical perspective of the discipline of dance.

Since the seminal neuroscientific and behavioral studies using dance were published [Calvo-Merino *et al.* 2005: 1243-1249, Jola *et al.* 2005: 217-237] the number of experimental studies on the cognitive and neuronal signatures in the human brain associated with dance has increased tremendously. The majority of neuroscientific studies that investigated brain processes involved in watching dance emerged in the remit of the so-called «mirror-neuron mechanisms» and looked at the so-called «action observation» processes. A typical study for example compared dancers' brain activity while they watched dance moves that they were physically familiar with to brain activity while watching dance moves with which they had little or no physical familiarity [Calvo-Merino *et al.* 2016: 1905-1910; Cross *et al.* 2006: 1257-1267; Cross *et al.* 2009: 315-326]. More recently, articles that relate to neurophysiological (e.g., respiration, heart rate, skin conductance) and/or cognitive benefits (e.g., spatial orientation, mathematical skills) based on dance training gained attention [Jola *et al.* 2017: 1-46].

Early neuroscientific studies that employed dance focused predominantly on western dance forms, such as classical ballet or contemporary dance [Orgs *et. al.* 2008] with the exception of Capoeira dance in the study by Calvo-Merino and colleagues [2006]. The spectrum of dance forms and critical considerations of socio-cultural and contextual appearances have since widened to social dances [Amoruso *et al.* 2014: 366-385], as well as dance forms from other cultures [Jola *et al.* 2012a]. It is important to note, however, that a critical discussion on the limitations of the scientific contrast of two dance styles such as by Brandon W. Shaw[forthcoming] is needed when comparing two dance styles, in particular if they are from different cultural backgrounds as in the study by Calvo-Merino and colleagues [2006] and in our own studies that compared spectators' responses to Bharatanatyam, a classical Indian dance, and to Ballet [Jola *et al.* 2012a; Jola *et al.* 2013: 90-98]. The latter points at another expansion of the content of the investigations by the sciences from dancers to other bodies involved in the performing arts: audiences [Jola *et. al.* 2012a; Jola and Grosbras 2013; Reason *et al.* 2016; Noble *et. al.* 2014; Grosbras, Tan & Pollick 2013; Herbec *et al.* 2015], choreographers [Stevens *et al.* 2010], as well as dance reviewers [Hee Jang & Pollick 2011]. Across all of these studies, empirical challenges remain. Some issues relate to the intangible quality of on- and off-stage 'presence', which is potentially one of the main reasons for the marginal number of empirical studies on cognitive and neuronal processes linked to theatre [Lippi *et al.* (forthcoming); Jola 2016;

Jola & Reason 2016]. In order to better understand the scientific mode of meaning-making, a more detailed but brief outline of the emergence of dance studies in the field of cognitive neuroscience is given below.

Background Mirror Neurons

Over the past decade, dance has received increased attention in neuroscientific research based on a coincidental finding by an Italian research team. This group of scientists found that neurons in motor areas of the monkey's brain fire not only during motor execution, as was expected, but also during passive action observation, which was an unpredicted observation [Rizzolatti *et al* 1996: 131-141]. These neurons were described as «mirror neurons» because of their functionality to fire both during the execution of an action as well as during the passive observation of an action, as if the neurons were motorically «mirroring» the action seen. Mirror neurons were found to be spread over the fronto-premotor and parietal area with a density of one in three [Kilner *at al.* 2013]. Direct evidence (actual brain activity) in humans is present, yet limited [Halje *et al.* 2015: 206-214; Mukamel *et al.* 2010: 750-756]. This is due to the required non-invasive brain activity measurement in humans by means of for example functional magnet resonance imaging (fMRI). In an fMRI experiment, the participant lies in a narrow tube (i.e., scanner) with a strong magnetic field. Protons in the human body align with the direction of this magnetic field. Their orientation is then further changed by applying energy through radio waves (RF pulses). After each pulse, protons realign to the magnetic field and release the energy applied. The time of the release after an RF pulse influences the strength of the signal that is measured as it differs dependent on the ratio of oxygenated (i.e., «fresh») to deoxygenated blood, thus giving an indication of the location of the most active areas in the brain, assuming active areas have higher oxygenated blood levels. While fMRI is a means to measure brain activity non-invasively, the interpretative steps and analytical tools from measurement to data interpretation (brain activity) are not without criticism and potential faults [Logothetis *et al.* 2016: 7900-7905]. Also, the spatial restrictions of the machine allow only small movements of the hands or feet. To achieve 3D models of the human brain activity, the head has to remain still and is thus immobilized throughout the scanning and whole body movements are not possible. Hence, most «mirror neurons» research in humans presented video clips to the passive, immobile spectator, thus focusing on passive action observation without identifying mirror neurons through overlapping activity in response to action execution and action observation. Also, while the resolution of non-invasive techniques has increased over time, it is currently impossible to measure the activity of individual neurons. Hence, in humans, it is not mirror neurons but action observation networks that are studied, with some exceptions [Gazzola *et al.* 2009: 1239-1255].

Initially, the assumptions were that mirror neurons are dependent on a biological effector (e.g., hand, mouth) and an object (e.g., piece of fruit), in other words, an actor performing a gesture, for example, of eating. The actor (whose action is observed), the precise execution of the action itself, the live presence of the actor, and the context in which the action was executed were considered irrelevant to the firing of the mirror neurons during passive action observation. These are of course all hugely important factors in the performing arts. Yet over time, it was found that mirror neurons were sensitive to these elements as well [Rizzolatti *et al.* 2014: 1-12]. Moreover, varied research approaches found evidence in support of a modality-independent system in the inferior frontal areas of the brain [Bachrach *et al.* 2016: 464-472], which shares the processing of performing, interpreting, and describing actions specifically and in different modalities (e.g., language, movement, music).

The discovery of mirror neurons was and still is intriguing for scientific endeavors as well as for the performing arts. Yet theoretical propositions including behavioral and neuronal evidences of a close link between perception and action are not new [Gibson 1954: 304-314]. Mirror neurons can be considered part of the neurophysiological evidence of a shared mechanism between perception and action [Van der Wel *et al.* 2013: 101-113]. As evident from the above, they have certainly sparked the thinking about how we initiate, monitor, and interpret our own actions and how the actions of others affect us. The understanding that our ability to interpret the actions of others through our own motor system has gained in pertinence and opened the receptiveness of neuroscience to study and employ embodied practices, such as dance.

Clearly, the applied link between action execution and action observation is ever so relevant for theatre practice. It fosters numerous yet unresolved questions regarding the power of the actor to captivate the audience through his or her actions [Sofia 2014: 313-332] (see also chapter by Sofia in this edition). Of particular interest is how an actor can achieve «spontaneity» in a gesture and maintain this effect in the spectators' reception despite having rehearsed and performed it numerous times. Other research that has evolved from the relationship between neuroscience and theatre is about actors training as a form of rehabilitation [Modugno *et al.* 2010: 2301-2313]. Moreover, the link to other modalities, such as language, music and conceptual/compositional perception are of relevance to the wider disciplines of the performing arts. The possibilities of gaining insight into what makes theatre work from a cognitive and neuroscientific point of view thus seem vast and yet utopian — due to the constraints of reductionist scientific paradigms as illustrated through the case of dance below.

CONSIDERATIONS IN EMPLOYING DANCE

Early experiments employed dance stimuli to test the mirror-neuron mechanism in an object-free context and evidence was reported that mirror neurons in humans respond to passively observed dance movements without objects being presented [Bläsing *et al.* 2012: 300-308; Sevdalis & Keller 2011: 231-236]. There are two considerations to be made underlying these findings.

Firstly, dance is a useful phenomenon to study the human brain and behavior while at the same time, it is a valuable subject of research in itself. Neuroscience predominantly employed dance as a tool to better understand the human brain and behavior. In some instances, however, the two approaches of meaning-making have been confused, such as when neuroscientific findings lead to propositions on how to make dance. In addition, I argue that an in-depth understanding of dance as a subject is required in order to employ it correctly in empirical research, even if the focus is on scientific advancements and not the study of dance itself. For example, dance is practiced across nearly all cultures. If not endangered with extinction due to political, religious or economic threats, dance is a universally prevalent and continuing practice, often refined into formalized styles. For reasons of comparison and clarity, the formalized dance styles are ideal for scientific research. However, it requires an in-depth understanding of the cultural embeddedness of the dance forms that allow informed selection and careful description as shown in the earlier example that compared dancers' brain responses watching capoeira with watching ballet moves.

Secondly, and as indicated above, most neuroscientific studies on brain activity while watching a dance performance, measure in fact passive action observation. Evidence of the mirror neuron network is therefore only partially provided. One of the underlying reasons is that movement during non-invasive brain measurements is very limited and that brain activity measurements in a non-moving participant are more accurate than in a moving participant. Hence, only few neuroscientific studies compared dancers' brain activity during action execution and action observation as would be required in the remit of mirror neurons [Brown *et al.* 2006: 1157-1167]. With recent methodological advances, such as wireless and affordable EEG technologies, more can be expected on this account. Moreover, in order to assess intricate differences in response to factors that are relevant in the performing arts, such as the presence of the performer, the structure of the movement sequence (or «movement phrase» in the dancer's terminology), or the visual experience and/or individual characteristics of an audience member, scientific studies are required to acknowledge dance stimuli that are of a lesser degree of reduction (see below).

Different Methodologies

The impact of neuroscience research is often placed at an excessively high level. A better understanding of the limitations of behavioral and neuroscientific approaches is therefore crucial to carefully interpret its findings. For instance, Cross and Ticini stated that «exploration of the neural mechanism associated with art appreciation, such as the biological reasons why certain works or performances are more popular than others, is undoubtedly of considerable artistic and commercial value» [Cross *et al.* 2006: 1157-1167]. Although the authors refer to Chatterjee's warning, that «it is critical for future studies in the neuro-aesthetic domain to be clear about what, precisely, neuroscientific data add to the study of aesthetics that behavioral experiments alone cannot achieve», a clear answer on what neuroscientific data add to a creative process is missing [Chatterjee 2011: 53-62]. There are several reasons to remain vigilant on the claims of what neuroscience can contribute to the value of performing arts.

Above all, there is a general tendency to over-rate neuroscientific findings as evidenced by Weisberg and colleagues [Skolnick *et al.* 2008: 470-477]. The authors showed that visual representations of brain activity influence the level of appreciation a reader has for research findings. In their study, participants were asked to read specifically constructed explanations for psychological phenomena with and without neuroscientific information. While all participants recognized what a good explanation of a research finding is, non-experts judged manuscripts that contained logically irrelevant neuroscientific information as more satisfying than those without neuroscientific contents. Participants therefore highly valued neuroscientific information, although it was not adding any relevant content. The authors explain that the neuroscientific content seems to be masking otherwise salient issues in bad explanations. Basically, this means that by adding a picture of a brain or a neuroscientific statement, the value attached to the writing has increased, whether the neuroscientific element contributes to the explanations or not. Hence, neuroscience information can mislead non-expert readers' understanding of bad explanations and it is therefore crucial to remain critical of what is the information that neuroscience actually adds.

In view of scientific meaning-making through the use of dance, it is important to look at what dance is as a phenomenon. For example, dance is considered an ephemeral art form. Dance practitioners are very much aware that dance changes, both over time and during the course of any given performance. This does not mean that dance is insubstantial or unserious but rather it emphasizes that «there is something vital about dance performances and events that disappears as it is being performed» [Bresnahan 2015]. Hence, when a dance performance is over, it generally leaves no artefact behind. At most, the dance lives on in the mind of the spectator and the bodies of the performers for a limited period of time (one could argue that for both, spectators and performers, traces of the dance continue to resonate to some extent in the body and the mind). Imagine, for example, asking participants to verbally report on two contrasting types of performances while their brain activity is being measured. It would certainly be challenging to analyze and interpret the data. This is based on several factors, such as the individual timings of the verbal reports, the participants' varied vocabulary, their speech activity that is not part of the study's interest, and the very individual experiences felt, remembered, and reported. However, considering what happens when we watch a dance performance on video, as has been done many times in the scanner, in which ways are these sensory and conceptual experiences affecting how dance is being seen? As these elements presumably vary hugely across individuals, brain imaging only allows interpretation of brain responses specific to the action contrast of the experiment itself (which is presumable the factor that is most salient across spectators). Yet this approach does not capture the lived experiences.

On the one hand, researchers have done little so far to consider the philosophical element of the ephemeral nature of dance or to counteract the disappearance of the dances they have used as stimuli. The latter is particularly important in order to link future research to the past: stimuli used in scientific experiments are rarely available in full to readers, despite advances in online technology. It begs the question how a movement that can be imagined with great difficulty on the basis of the description in a just published manuscript, can possibly be understood a few years later (considering that dance is a continuing, evolving phenomenon). Moreover, based on the knowledge of how much even relatively formalized styles of dance, such as ballet [Daprati *et al.* 2009: e5023] change over time, more attention should be drawn to how meaning-making from dancers, audiences, and dance scholars could be incorporated into scientific work.

On the other hand, if one were to acknowledge the importance of the ephemeral character of dance, studying responses to live performance would be the way forward. In line with the identified sensitivity of mirror neurons in response to live versus video presentations [Kilner *et al.* 2013], we found that novice spectators showed enhanced sensorimotor responses to live actions that are recognized as everyday gestures. This was true also for gestures that were culturally unfamiliar to its spectators. In other words, watching dance live may increase audiences' meaning-making. Other studies using live versus TV presentations or stills (independent of dance) showed similar findings with enhanced sensorimotor responses to live compared to digital presentations [Pönkänen *et al.* 2011: 486-494; Shimada *et al.* 2006: 930-939]. Clearly, the complexity of the visual environment and the spontaneity of a live performance is a challenge to the scientific paradigm of reliability (i.e., consistency of measurement), no one live performance is the same. However, the very factors of a live performance that can be considered a reduction of reliability (the performers' variability) is at the same time a counteracting element (the performers' ability to adjust performance to audience members' engagement, timing of the day, and so on). However, due to convenience, funding limitations, and common scientific approaches to experimental research, dance is generally presented in form of digital stimuli.

Further, considering that there is often a big difference between a work of art and the representation of that work used for scientific research [Christensen *et al.* 2015: 223-252], readers and reviewers of neuroscientific publications should remain vigilant to this gap and its implications on the findings. One of the most common and evident reductions is the presentation duration of the stimuli. Dance stimuli in neuroscientific studies are commonly of very short duration (e.g., often between 3 and 16 secs duration). It is obvious that audiences would not be happy to pay for a dance performance that is no more than a random appearance of 3 second actions. It is worth noting that most scientific experiments do not consider dramaturgical or set design choice making processes. Under these circumstances, I argue that it is inappropriate to assume that the findings from neuroscience can have a considerable artistic and economic impact on dance. Although the claim is based on the assumption that research findings are representative and valid beyond the context of the experimental laboratory, it ignores findings that showed significant differences in spectators' responses depending on the form of presentation.

It should be noted that novel means of recording and analyzing complex brain imaging data have allowed to present participants with longer sequences of dance phrases. Overall, these studies emphasize that a coherent structure of the dance movements enhance the activity of the action observation network. The level of understanding on how the brain processes movement sequences and action chains does not yet add direct knowledge to the toolbox of an experienced dance maker. I would therefore argue that for the time being, it is predominantly dance that supports meaning-making in science: i.e., the various styles of dance that inform science about scientific limitations, about human brain mechanisms, and how brain processes and socio-cultural phenomena may be linked.

TYPES OF CHALLENGES

Awareness of some of the methodological challenges in employing dance for scientific research discussed above have been raised in earlier publications on the coupling of dance and neuroscience [Jola *et al.* 2007: 62-67; Jola 2010: 203-234]. Despite criticism and glimpses of paradigm shifts within the sciences towards a more ecologically valid approach with methods, materials, and settings of a study being closer to the real-world phenomena examined [Risko *et al.* 2012: 1-11; Redcay *et al.* 2010: 1639-1647], making sensible use of dance to study the human brain and behavior remains a challenge (see Table 1). The issues outlined in Table 1 are not intended to be exhaustive but provide a selection of factors that influence the modes of meaning-making. The output forms may seem legitimate considering the very different discipline aims, however, it is one of the aspects that cause numerous challenges.

To facilitate the understanding of the challenges in combining dance and cognitive neuroscience, I propose to differentiate between soft and hard problems. Soft problems are differences between disciplines such as dance and neuroscience that can be overcome by individuals, such as breaking down language barriers, recognizing different types of knowledge, acknowledging and potentially softening discipline cultures, and increasing the understanding of dance from different perspectives. Hard problems, such as the ranking of disciplines' output, the funding structures, the methodologies used, and the forms of dissemination are all closely linked to differences in output and take more time and effort for change to be implemented. It also requires a number of key experts to shift perceptions rather than a small group or individuals' engagement.

	Cognitive Neuroscience	Dance
Research practice	Shared consent of complying to a set of principles, objectivity is important, paradigm shifts are slow	Individualistic approaches, continued redefining, subjective experience is highly valued during creation
Type of Knowledge	Shared, specific but generalisable, accessible, verifiable, replicable, based on empirical evidence	Individual, subjective, broad, based on empirical or practice based research
Chance procedures	High efforts for control; yet at times chance observations provided highly valued insights	Space provided to chance procedures; at times chance is the defining element of a work
Output Forms	Peer reviewed manuscript, targeted audiences are expert scientists	Idiosyncratic performances, inclusive audience targeting
Aesthetic value	Frequently of low quality and generally not evaluated; occasionally even in the context of the study of aesthetic perception	Valued highly, of high importance

Table 1. Selection of factors that identify differences between research in Cognitive Neuroscience and Dance.

For example, although the number of interdisciplinary research collaborations has increased, the funding culture remains rigid. As has been shown for Australian applications, interdisciplinary research has had consistently lower funding success than basic research within a discipline [Bromhan 2016: 694-687]. With less funding, output and impact are more limited. Further, indicated in Table 1, scientists focus on peer reviewed manuscripts that are targeted at an expert readership. In contrast, dance aims to stage idiosyncratic performances and want to be inclusive, ideally, by reaching dancers and audiences across a wide socio-economic and cultural spectrum. There are other strings attached to research output: most journals who follow a peer-review publication approach, have a so-called impact factor assigned, which is the average number of citations received per article published in that journal during preceding years. The more an article is cited, the higher its value is estimated and the more citations the articles in a journal receive, the higher is the impact value of the journal. Consequently, researchers want to publish in journals with a high impact factor. Yet impact factors are dependent on how many recorded publications appear within a given discipline and scientific journals achieve higher impact factors than for example journals in the social humanities, dance scholarship, or journals that are prepared to publish interdisciplinary work. Therefore, the estimated impact of an output is likely to remain lopsided.

Last but not least, an ever faster growing output leads to the impression of a production assembly line. To minimize criticism, it is convenient for scientists to conduct their research within the boundaries of established scientific paradigms, which are predominantly based on reductionist mechanisms. Hence, such an aligned approach enhances the speed of publication and a higher impact factor is more likely achievable. Yet this leaves little or no space for the non-intended to unfold. This is somewhat of a paradox, considering that the foundation of the exponential increase in dance and neuroscience studies is based on a coincidental observation as described above.

In an attempt to allow the performing arts practice to achieve research status —as defined by established scientific disciplines—, the term «Practice as Research» has been introduced [Nelson 2013]. While Practice as Research allows a theoretical framework to situate artistic practice within higher education, it can be considered an oddity: it is evident that artists who have created works of high artistic, historical, and cultural value, have always conducted research within their field. Similarly, dance as any other art form, has long done its own type of research before higher education accreditation. Moreover, science also has a «research practice», but its practitioners generally do not reflect on it. A stronger focus on practice as research from within the sciences could potentially enhance ecological validity and aesthetic value by raising the awareness for participants' experience. Notably, reflections on research practice have increased in the sciences, as evident for instance through the increased efforts to acknowledge and push for preregistration of studies. Notably, preregistration most beneficial to the more rigid paradigm-oriented reductionist experimental approaches and could potentially provide a false understanding of position as employed in explorative research. Moreover, while preregistering increases our trust in the hypothesis testing, the process ignores potential pitfalls in ecological validity and increase the risk of crediting studies irrespective of their limited ecological value. As discussed above, effects of spectators' individual experiences are recognized as modes of meaning-making in dance, hence, when dance is used for meaning-making in the sciences, individual differences and factors of personality require consideration.

Notably, one could argue that there is «no one dance» and there is «no one spectator» —which lets us step into the intricacies of art, and the common approach to meaning-making through «mean» calculations in the sciences.

OUTLOOK

Having presented my research at cross-disciplinary conferences for over more than fifteen years, it has become evident that the interest in and engagement with the mirror neuron concept has dramatically increased within the dance and theatre sector. Similarly, increasing numbers of individuals who work and research at the intersection of the performing arts and the cognitive neurosciences have attended the manifold novel forms of workshops, conferences, and publications combining the performing arts and the sciences, thus enhancing the understanding across the fields. The introduction on the neuroscientific background has thus been kept deliberately short here and the interested reader is recommended to consult the literature beyond this chapter [Sevdalis & Keller 2011; Bläsing *et al.* 2012; Johnson & Shiffar 2013; Karpati *et al.* 2015].

A central question for future of cross-disciplinary research proposedly is: how does an ideal performing art-science project look like? To plough a path through the muddle of challenges I proposed that the parties continue with combined efforts, namely that scientists embody dance, that artists engage with science, and that audiences participate as researchers. To describe these activities, I suggested the terms *experimental choreography* and *embodied neuroscience*. With *experimental* in experimental choreography, I do not refer to its common use of trial and error, but the sense of performances designed in an experimental way that entails at the same time artistic and scientific value. The latter, *embodied neuroscience*, asks the researcher to take part in the physical practice of his research object. The rationale is that the study is grounded on experiential knowledge in order to inform what aspects of which type of dance are relevant to not strip off the form for reductionist arguments. Challenges are still well known: experimental choreography requires a funding structure that is uncommon for scientific research and embodied neuroscience works against the scientific discipline culture in terms of social interaction as well as the pressure to publish or perish.

To conclude, understanding the different meaning-makings of the scientist, the practitioner and the audience, where could neuroscience meet theatre practice? The meeting point of theatre practice and neuroscience has followed a different historical trajectory from the coupling of dance and neuroscience: the neuroscientific stance within the acting discipline started in pedagogy and education — it is just that it coincided with mirror neuron findings. Hence, according to Sofia, the investigations were spread broader from the beginning (i.e., with four trajectories: physiology of action, physiology of emotions, ethology, and studies on spectator's perception). At present, effects of training do have a strong position in the performing arts —even if it is limited to making use of the spark that neuroscience creates to think and reflect, without adding any direct relevant information (if one were to remain aware of the difference between adding knowledge and supporting the creation of knowledge). It can be hoped that in a second and third step, neuroscience may approach and reveal existing myths in theatre and with it advance the future of dance-neuroscience research.

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